An Analysis of the New Japanese Payment System for Cataract Operations

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***Abstract*-Based on the report of the Central Social Insurance Medical Council concerning 2002 Revision of the Medical Service Fee Schedule, a new inclusive payment system based on the Diagnosis Procedure Combination (DPC) was introduced in Japan in April 2003. At the beginning of April in 2004, the system was gradually extended to general hospitals that satisfied certain required conditions. This was one of the largest and most important revisions of the payment system since the Second World War. One of the major purposes of the DPC-based payment system is to reduce the length of hospital stay. However, since the the system was introduced only recently, sufficient evaluations of the system have not been done. In this paper, we present our analysis of the effects of the new inclusive payment system on the length of hospital stay following cataract operations (DPC Category Code: 020110) in Japan. Data collected from 5 general hospitals before and after the introduction of the system were analyzed. The number of patients was 2,533. The results of the study strongly suggest the necessity of revising the payment system to more efficiently use medical resources in the future.**

Keywords-Survival Analysis; Inclusive Payment System; Length of Hospital Stay; Diagnosis Procedure Combination (DPC); Cataract Operation

I. INTRODUCTION

In 2005, the average length of stay (ALOS) of general hospitals in Japan was 19.7 days [1]. The ALOSs in other countries were: 10.2 days in Germany， 13. 4 days in France，7. 0 days in England，and 6.5 days in the United States [2]. Since the Japanese ALOS was much longer than those of other nations, shortening the ALOS by reducing long-term hospitalizations has become an important political issue in Japan.

The new inclusive payment system based on the Diagnosis Procedure Combination (DPC) was introduced in 82 special functioning hospitals (i.e., university hospitals, the National Cancer Center, and the National Cardiovascular Center) in April 2003 [3] [4]. (In the rest of this paper, we refer to the new payment system based on the DPC as the DPC system.) Since April 2004, the DPC system has been gradually extended to general hospitals. Until July 2010, a total of 1,391 hospitals, comprising about 18% of the 7,714 general hospitals in Japan, had joined the DPC system. These hospitals have 458,707 beds, which represents half of the total number of beds (909,337 beds) out of all general hospitals. Unlike the Diagnosis-Related Group/ Prospective Payment System (DRG/PPS) used in the U.S. and other countries, the Japanese DPC system is a per diem prospective payment system, with the per diem payment decreasing as the LOS becomes longer. (Details of the DPC system are given in the appendix.) The introduction of the DPC system was one of the largest and most important revisions of the payment system since the Second World War. To ensure the effective use of medical resources, it is absolutely necessary to thoroughly analyse the DPC system to identify needed improvements. However, since the system was introduced recently, sufficient evaluations of the system have not yet been done. Although the DPC Evaluation Division of the Central Social Insurance Medical Council [5] [6] published reports about the effects of the DPC system, these reports are no more than simple comparisons of the ALOSs.

In this paper, we present our analysis of the length of stay (LOS) in a hospital for cataract operations before and after the introduction of the DPC system. The number of cataract patients in Japan has been increasing rapidly with the ageing of the population. According to a survey conducted by the Ministry of Health, Labour and Welfare [7], nearly 800,000 cataract operations are performed annually and nearly 2.5 billion yen is spent on cataract operations annually. The overall difficulty level of surgical and treatment procedures for cataracts is not high, owing to their standardization, and the outcomes are generally predictable. Moreover, most cataract operations are scheduled in advance, and the likelihood of postoperative infections or complications is very low. Fedorowicz, Lawrence and Guttie [8] found no significant difference in outcome or risk of postoperative complications between day care and inpatient cataract surgeries. Thus cataract cases are considered to be a highly suitable candidate for evaluating the various aspects of the DPC system.   We analyse the influence of the DPC system and factors that might affect the LOS for cataract patients by examining data collected from 5 general hospitals before and after the introduction of the system. To eliminate the influence on the types of operations and treatments, we use data strictly pertaining to patients who underwent a cataract operation and the insertion of a prosthetic lens in one eye only. The number of such patients was 2,533.

II. MODEL

Cox's proportional hazard model [9] is widely used to examine various problems in survival analysis, such as the LOS. However, we cannot use the proportional hazard model when heterogeneity exists in the baseline hazard function. For the LOS, variances are often heterogeneous even after controlling for the characteristics of diseases, treatments, and patients. Therefore, it is improper to use the proportional hazard model for such a data set. Nawata et al. [10] analysed the LOS for hip fracture patients using a simultaneous equation model. However, even in their model, the heterogeneity of variances was not considered. In this paper, we first propose a new model that considers the heterogeneity of variances.

The LOS (number of days) is a discrete-type variable taking positive integers (1,2,3,…). Moreover, the skewness and kurtosis values are often large. Let i be the sample period and n_i be the number of patients in the period i. (Since we consider two periods, one before and one after the introduction of the DPC system, the value of i is either 1 or 2.) Suppose that the revenue and cost of the hospital for the jth patient are b_{ij} and c_{ij} , respectively. The revenue includes not only direct monetary payments but also improvements in its asset value owing to high-quality medical services, and the cost also includes an opportunity cost arising from the loss of revenue that the hospital suffers because of the unavailability of beds for new patients. Let

$$g(t, x_{ij}, v_{ij}) = \frac{\partial c_{ij}}{\partial t} - \frac{\partial b_{ij}}{\partial t} \tag{1}$$

Where t is the LOS, x_{ij} is a vector of explanatory variables affecting the hospital's revenue and cost, and v_{ij} is an unobserved error term. The function $g(t)$ is assumed to be an increasing function of t. As in many previous studies, we assume that

$$z_{ij}(t) \equiv g(t, x_{ij}, u_{ij}) = t^{\alpha} - (x_{ij}'\beta + v_{ij}),\ \alpha \geq 0. \tag{2}$$

When patients who have stayed in hospitals for long periods before eventually exit, α becomes less than one. The variances are quite different depending on the sample period. Hence we do not assume homoskedasticity of variances, and v_{ij} is assumed to follow the normal distribution with a mean of 0 and a variance of σ_i^2 . (If we use $(t^{\alpha}-1)/\alpha - (x_{ij}'\beta^* + v_{ij}^*)$ and $v_{ij}^* = v_{ij}/\alpha$, we get an identical model. Thus, we can consider the model to be a version of the Box-Cox transformation model [11] widely used in various fields.) We insert a minus sign and make $-(x_{ij}'\beta + v_{ij})$ in Equation (2) so that the LOS increases as the value of $x_{ij}'\beta$ becomes larger. To remove the influence of the small number of patients who stayed at the hospital for a long period of time, we choose T as the maximum number of days at the hospital. For patients staying more than T days, we only use the information that their stay exceeded T days.

The LOS is a discrete variable taking positive integers. The condition for the jth patient in the sample period i being discharged from the hospital on the t_{ij} is given by

$$\begin{aligned} &z_{ij}(t_{ij}) \geq 0, && t_{ij} = 1 \\ &z_{ij}(t_{ij}-1) < 0,\ z_{ij}(t_{ij}) \geq 0, && t_{ij} > 1. \end{aligned} \tag{3}$$

The probability of the patient being discharged from the hospital on t_{ij} is given by

$$P_{ij} = \begin{cases} P[t_{ij}^{\alpha} - x_{ij}'\beta \geq v_{ij}], & t_{ij} = 1 \\ P[(t_{ij}-1)^{\alpha} - x_{ij}'\beta < v_{ij} \leq t_{ij}^{\alpha} - x_{ij}'\beta], & 1 < t_{ij} \leq T. \end{cases} \tag{4}$$

Let Φ be the distribution function of the standard normal distribution. We get

$$P_i = \begin{cases} \Phi\{(t_{ij}^{\alpha} - x_{ij}'\beta)/\sigma_i\}, & t_{ij} = 1 \\ \Phi\{(t_{ij}^{\alpha} - x_{ij}'\beta)/\sigma_i\} - \Phi[\{(t_{ij}-1)^{\alpha} - x_{ij}'\beta\}/\sigma_i], & 1 < t_{ij}. \end{cases} \tag{5}$$

The probability of the patient staying at the hospital for more than T days is given by

$$P[T^{\alpha} - (x_{ij}'\beta + v_{ij}) < 0] = 1 - \Phi\{(T^{\alpha} - x_{ij}'\beta)/\sigma_i\}. \tag{6}$$

From Equations (5) and (6), we obtain the likelihood function given by

$$\begin{aligned} L(\alpha, \beta, \sigma_i) = &\prod_{t_{ij}=1} \left[\Phi\{(t_{ij}^{\alpha} - x_{ij}'\beta)/\sigma_i\}\right] \\ &\times \prod_{1<t_{ij}\leq T} \left[\Phi\{(t_{ij}^{\alpha} - x_i'\beta)/\sigma_i\} - \Phi[\{(t_{ij}-1)^{\alpha} - x_{ij}'\beta\}/\sigma_i]\right] \\ &\times \prod_{t_{ij}>T} \left[1 - \Phi\{(T^{\alpha} - x_{ij}'\beta)/\sigma_i\}\right]. \end{aligned} \tag{7}$$

However, in this function, the parameters are in a complicated form, and the estimation is not easy. We therefore propose a new model that can easily make the estimation using a standard statistical package program. The method is based on an approximation of the likelihood function.

Considering the first-order Taylor expansion, we get

$$\begin{aligned} &\Phi\{(t_{ij}^{\alpha} - x_{ij}'\beta)/\sigma_i\} - \Phi[\{(t_{ij}-1)^{\alpha} - x_{ij}'\beta\}/\sigma_i] \\ &\approx \frac{1}{\sigma_i}\phi[\{(t_{ij}-\frac{1}{2})^{\alpha} - x_{ij}'\beta\}/\sigma_i]\alpha(t_{ij}-\frac{1}{2})^{\alpha-1}. \end{aligned} \tag{8}$$

To make the approximation more accurate, we evaluate the derivative at $t_{ij} - \frac{1}{2}$. When the value of $\Phi(-x_{ij}'\beta/\sigma_i)$ is small, Equation (8) can be used for $t_{ij} = 1$. The log of the likelihood function is approximated by

$$\begin{aligned} &\log L^*(\alpha, \beta, \sigma_i) \\ &= \sum_{t_{ij}\leq T} \left[\log \phi[\{(t_{ij}-\frac{1}{2})^{\alpha} - x_{ij}'\beta\}/\sigma_i] - \log \sigma_i\right] \\ &+ \sum_{t_{ij}\leq T}^{n} \{\log\alpha + (\alpha-1)\log(t_{ij}-\frac{1}{2})\} \\ &+ \sum_{t_{ij}>T} \log[1 - \Phi\{(T^{\alpha} - x_{ij}'\beta)/\sigma_i\}]. \end{aligned} \tag{9}$$

The second term of Equation (9) does not depend on β . When α is given, the estimator $\hat{\beta}_{\alpha}^*$, which maximizes $\log L^*$, is obtained by maximizing

$$\begin{aligned} \log L_{\alpha}(\beta, \sigma_i) = &\sum_{\tau_{ij}<c} \left[\log \phi[\{(\tau_{ij} - x_{ij}'\beta\}/\sigma_i] - \log \sigma_i\right] \\ &+ \sum_{\tau_{ij}\geq c} \log[1 - \Phi\{(c - x_{ij}'\beta)/\sigma_i\}], \end{aligned} \tag{10}$$

where $\tau_{ij} = (t_{ij} - \frac{1}{2})^{\alpha}$ and $c = T^{\alpha}$. Suppose that the first element of x_{ij} being 1. Let $\tau_{ij}^{*} = c - \tau_{ij}$, and let β^{-} be a vector of parameters given by

$$\beta_1^{-} = c - \beta_1, \quad \beta_m^{-} = -\beta_m, m \geq 2, \tag{11}$$

where β_m and β_m^{-} are the *m*th elements of β and β^{-}, respectively. In this case, the model becomes a standard tobit-type model (censored regression model) given by

$$\tau_{ij}^{**} = -x_{ij}'\beta + c + \varepsilon_{ij} \equiv x_{ij}'\beta^{-} + \varepsilon_{ij}, \tag{12}$$

$$\tau_{ij}^{*} = \begin{cases} \tau_{ij}^{**} & \tau_{ij}^{**} > 0 \\ 0 & \tau_{ij}^{**} \leq 0 \end{cases}, \text{ and } \varepsilon_{ij} \sim N(0, \sigma_i^2)$$

The estimator $\hat{\beta}_{\alpha}$, which has the same asymptotic distribution as $\hat{\beta}_{\alpha}^{*}$, can be obtained easily by performing the following steps using a standard statistical package program:

i) Estimate Equation (12) by the tobit maximum likelihood method, and calculates $\hat{\sigma}_i^2$, which is the estimator of σ_i^2, for each value of *i*.

ii) Adjust the heteroskedasticity by dividing the variables by $\hat{\sigma}_i$.

iii) Estimate β^{-} using the adjusted data set, and calculate $\hat{\beta}_{\alpha}^{*}$ from Equation (11).

Note that the standard tobit maximum likelihood estimator is not consistent under heteroskedasticity, so it is necessary to estimate $\hat{\sigma}_i^2$ and adjust the heteroskedasticity. Next, we can obtain the estimators $\hat{\alpha}$ and $\hat{\beta}$ by maximizing $\log L^{*}(\alpha, \hat{\beta}_{\alpha})$ with respect to α. Here, considering the possibility that $\log L^{*}(\alpha, \hat{\beta}_{\alpha})$ has plural local maxima, we employ th] scanning method [12] [13] for $0 < \alpha \leq 1$.

III. DATA

A. Hospitals

In this study, we use two data sets, one collected before and one collected after the introduction of the DPC system. The first period is from April 2000 to March 2001, before the introduction of the DPC system. The data set was collected from 36 hospitals participating in the Project for Information Standardization and System Developments in Efficient Hospital Management. The second period is from April 2005 to December 2007, after the introduction of the DPC system. The data set was collected from 86 hospitals by the Section of Health Care Economics, Tokyo Medical and Dental University.

When a patient has a secondary disease or complications, the LOS is expected to be longer. To eliminate this effect, we analyse only patients who underwent a one-eye cataract operation and an insertion of a prosthetic lens (pseudophakos). Patients who underwent other types of operations or treatments were eliminated from the data set. Owing to the standardization of cataract operations, the homogeneity of the data in the two sample periods is considered to be high. We analysed the data collected from 5 general hospitals (Hp1-Hp5) in which more than 10 patients were reported in each of the two periods. The number of beds in these hospitals ranges from 440 to 1,109, with an average of 688 beds. The total number of patients was 2,533, including 1,567 in the first period and 966 in the second period.

B. Length of Hospital Stay

Summaries of the LOSs for the two studied periods are given in Table 1. In the first period, the ALOS and standard deviation for all patients were 5.99 days and 10.45 days, respectively. The minimum ALOS by the hospital was 3.96 days (Hp1), and the maximum was 9.26 days (Hp2). In the second period, the ALOS and standard deviation for all patients were 4.11 days and 1.08 days, respectively. The ALOS was shortened by 1.88 days, and the standard deviation was 1/8 of that in the first period. The minimum ALOS by the hospital was 3.61 days (Hp3), and the maximum was 9.26 days (Hp5). For four hospitals (Hp2-Hp5), the ALOSs were shortened by 2.22 ~ 4.73 days in the second period. The ALOS for Hp1, which the ALOS was the shortest in the first period, increased by 0.04 days in the second period. As a result, the ALOS for Hp4 became the shortest of the hospitals studied. The differences in ALOSs among hospitals decreased substantially in the second period.

TABLE 1. LOS BY HOSPITAL IN THE FIRST AND SECOND PERIODS

Hospital	Period	Number of patients	Average	Standard deviation
Hp1	first	1036	3.96	1.24
	second	725	4.00	0.24
Hp2	first	65	9.28	15.29
	second	12	5.50	1.24
Hp3	first	355	8.91	20.22
	second	91	4.18	0.66
Hp4	first	30	5.83	2.12
	second	98	3.61	1.31
Hp5	first	81	8.96	3.74
	second	40	6.03	3.11
All	first	1567	5.59	10.45
	second	966	4.11	1.08

*: The first period is 1999-2000, and the second period is 2005-2007.

C. Explanatory Variables

We chose the following variables as explanatory variables. The Female Dummy (0: male, 1: female) was used for gender. The proportions of females were 62.3% and 63.6% in the first and second periods, respectively. Concerning the ages of patients, we used the following age dummies: Under 40 (1: under 40, 0: otherwise), Age 40 (1: 40-49, 0: otherwise), Age 50 (1: 50-59, 0: otherwise), Age 60 (1: 60-69, 0: otherwise), Age 70 (1: 70-79, 0 otherwise), Age 80 (1: 80-89, 0 otherwise), and Age 90 (1: 90 or over, 0: otherwise). The average ages of the patients (with standard deviations in parentheses) were 73.7 (9.7) and 75.4 (8.8) for the first and second periods, respectively. The average age in the second period was 1.7 years higher than that in the first period. To represent the place to which patients went after hospitalization, we used the Not Home Dummy (0: returning home, 1: otherwise). In this study, 37 and 2 patients did not return home in the first and second periods, respectively. Four Hp*k*

Dummies (1: Hp*k*, 0: otherwise, $k = 2,3,4,5$) were used to represent the influences of the hospitals. The base of these variables is Hp1, where the ALOS was the shortest in the first period. For the influence of the sample period, the Second Period Dummy (0: first period, 1: second period) was used. Since the influence of the DPC system might differ among the hospitals, the products of the hospital dummies and Second Period Dummy (Hp*k* Dummies × Second Period Dummy) were also included as explanatory variables.

IV. RESULTS OF THE ESTIMATION

We considered two different periods. The periods i =1 and i =2 refer to the first period and second period, respectively. Therefore, $x_{ij}'\beta$ of Eq. (2) becomes

$$\begin{aligned} x_{ij}'\beta = {} & \beta_1 + \beta_2 \text{ Female Dummy} \\ & + \beta_3 \text{ Under 40 Dummy} + \beta_4 \text{ Age 40 Dummy} \\ & + \beta_5 \text{ Age 50 Dummy} + \beta_6 \text{ Age 60 Dummy} \\ & + \beta_7 \text{ Age 80 Dummy} + \beta_8 \text{ Age 90 Dummy} \\ & + \beta_9 \text{ Not Home Dummy} \\ & + \beta_{10} \text{ Second Period Dummy} \\ & + \sum_k \beta_{k'} \text{ Hp } k \text{ Dummy} \\ & + (\text{Hp}k \text{ Dummy} \times \text{Second Period Dummy}). \end{aligned} \tag{13}$$

To eliminate the influence of the small number of patients who stayed at the hospital over a long period of time, we selected T = 12. A total of 57 patients–2. 2% of all patients included in the study—stayed at the hospital for more than 12 days.

Table 2 presents the estimates for α and β . The estimate for α was 0.5322, which is significantly smaller than 1.0. This implies that some patients remained at the hospital for a long period of time.

The estimate for the Female Dummy was positive and significant at the 5% level, which implies that females stayed at the hospital longer than males. Concerning the ages of the patients, the estimate for the Age 50 Dummy was negative and significant at the 1% level, and that in the Age 90 Dummy was positive and significant at the 5% level. The estimate for the Under 40 Dummy was negative, and the estimates for the Age 40 and Age 80 dummies were positive but not significant at the 5% level. The estimate for the Not Home Dummy was positive and significant at the 1% level, and the LOS became longer if the patient did not return home after hospitalization.

All estimates of the hospital dummies were positive and significant at the 1% level. The estimate of the Second Period Dummy was positive and significant. This implies that the LOS did not decrease but rather increased in the second period for Hp1. On the other hand, the estimates of the (Hp*k* Dummy × Second Period Dummy) became negative and significant at the 1% level for Hp2-Hp5, and the LOSs in these hospitals decreased in the second period. Moreover, the reduction was larger as the ALOS in the first period was longer.

The estimates of decreased from $\hat{\sigma}_1 = 0.422$ in the first period to $\hat{\sigma}_2 = 0.227$ in the second period. The *t*-value for the null hypothesis of the homogeneity of variances was quite large (22.30**)**. This hypothesis was rejected at the (any reasonable) significant level. It was shown that the variance decreased in the second period, and the importance of the proposed model was strongly suggested.

TABLE 2. RESULTS OF ESTIMATION

Variable	Estimate	Standard error	*t*-value
Constant	1.8897	0.01731	109.168 **
Female Dummy	0.0340	0.01524	2.2318 *
Age Dummies			
Under 40	-0.1658	0.09616	-1.7236
Age 40	0.1000	0.09090	1.1001
Age 50	-0.0929	0.03437	-2.7033 **
Age 60	-0.0169	0.02010	-0.8407
Age 80	0.0290	0.01770	1.6389
Age 90	0.1240	0.05297	2.3407 *
Not Home Dummy	0.4513	0.06271	7.1962 **
Hp2	0.8382	0.04773	17.5596 **
Hp3	0.6251	0.02350	26.5959 **
Hp4	0.4744	0.06828	6.9477 **
Hp5	1.0646	0.04309	24.7046 **
Second Period Dummy	0.0264	0.01284	2.0621 *
Hp*k* Dummies ×Second Period Dummy			
Hp2	-0.4405	0.11738	-3.7529 **
Hp3	-0.5538	0.04705	-11.7695 **
Hp4	-0.5461	0.07828	-6.9755 **
Hp5	-0.6209	0.07379	-8.4143 **
α	0.5322	0.01441	36.9326 **
σ_1	0.4346	0.00799	54.3685 **
σ_2	0.2256	0.00511	44.1181 **
$LogL^*$	-4541.549		

*: Significant at the 5% level. **: Significant at the 1% level.

V. EVALUATION OF THE DPC SYSTEM

The results of the previous section suggest that i) the LOSs changed between the first and second periods, ii) the effects were different among hospitals, and iii) the deviation of the LOS decreased in the second period. Naturally, these changes might have been caused by the introduction of the DPC system. However, since several years passed between the two periods, other factors, such as technical innovations and revisions of medical processes in hospitals, might also have caused these changes. Therefore, it is necessary for us to verify whether the changes were caused by the DPC system. In this section, we first analyse the influences of the DPC system on the LOS. Then, comparing our findings with the empirical results presented in the previous section, we investigate whether the changes in the LOS were caused by the use of the DPC system.

A. *Influences of the DPC System*

We first evaluate the influences of the DPC system on the LOS. The DPC system affected hospitals with respect to three points. The first point is the revenue of the hospital. The marginal revenue is the amount of daily inclusive payment, and this daily payment has increased for stays below Period I.

Therefore, there is little (or no) incentive for a hospital if the ALOS was already short (we refer to this type of hospital as a short ALOS hospital) to reduce the LOS. It is possible that hospitals would keep patients longer than necessary until Period I. On the other hand, for a hospital where the ALOS was long (we refer to this type of hospital as a long ALOS hospital), the reduction of revenue becomes a serious problem. The marginal revenue is a decreasing function of time and becomes smaller amount than that of the conventional fee-for-service system. Since the LOS is given by Equation (3), the hospital reduces the number of patients who stay at the hospital for long periods if the marginal cost does not change.

The second point concerns the hospital's reputation. The periods determined by the DPC system represent the standard LOSs, which were not explained clearly to patients before the introduction of the DPC system. For a nationwide comparison of hospitals is easy because of the DPC system, the damage in reputation to a hospital due to criticism for keeping patients for unnecessarily long periods can be serious. Based on this point, the incentive to reduce the LOS is weak in the short ALOS hospital and strong for the long ALOS hospital.

The third point is the revision of the medical treatments in the hospital through the computerization of medical information. Unlike the DRG, the DPC contains not only information about payments but also information about patients, treatments, and operations. Therefore, it helps the hospital to improve and standardize the medical treatments through the introduction of clinical paths, the adoption of proper medical technology [14], and the proper management of hospitalization schedules [15]. It is reasonable to consider that the standardization of medical treatments was advanced in short ALOS hospitals, and this effect also occurred in long ALOS hospitals.

From the analysis above, we conclude that the three points have similar effects on the LOS. We can thus form the following hypothesis: "The DPC system affected the LOS. However, the influences were rather different among hospitals. The DPC system gave strong incentives to reduce the LOS for the long ALOS hospital but weak (or no) incentives to do so for the short ALOS hospital."

B. Comparison of the Hypothesis and the Empirical Results

To evaluate the effects of the DPC system, it is necessary to consider the changes in the characteristics of patients. If the change of the LOS between the two periods was caused by the changes in characteristics of patients, we cannot say that it was influenced by the DPC system. Here, we analyse the LOS while controlling for the patient characteristics. Table 3 represents the ALOSs in the first and second periods and the number of days by which the ALOS decreased in the second period (for Hp1, since the ALOS increases in the second period, the value becomes negative for Hp1) for a male patient in his 70s who returns home after hospitalization, according to the hospital.

The ALOSs for all hospitals were 6.23 and 4.52 days in the first and second periods, respectively, and thus the decrease was 1.71 days. The ALOSs decreased by 1.53, 2.10, 1.95, and 2.72 days in the second period for Hp2-Hp5, respectively. On the other hand, for Hp1, where the ALOS was 3.90 days and was the shortest in the first period, the ALOS increased by 0.09 days to 3.99 days. As a result, the ALOS for Hp4 became shorter in the second period. The standard deviation among hospitals was approximately cut in half; it decreased from 1.63 days to 0.83 days in the first and second periods, respectively. The correlation coefficient between the ALOSs in the first period and numbers of reduced days is 0.897. The null hypothesis that the correlation coefficient is zero is rejected at the 1% level. In other words, variations of the ALOSs among hospital decreased by a large amount in the second period, and the reduction was larger as the ALOS in the first period was longer.

The hypothesis given in 5.1 is consistent with this result. It can explain the changes of the LOS well, and the hypothesis that the DPC system might have caused these changes is supported. Therefore, for further reduction of the LOS in cataract operations, it is necessary to revise the payment system to give incentives to use medical resources intensively in a short term.

TABLE 3. THE ALOSS WHILE CONTROLLING FOR THE PATIENT CHARACTERISTICS BY HOSPITAL

Hospital	First period	Second period	Number of days decreased
Hp1	3.90	3.99	-0.09
Hp2	7.16	5.31	1.85
Hp3	6.24	4.14	2.10
Hp4	5.62	3.67	1.95
Hp5	8.22	5.50	2.72
Average	6.23	4.52	1.71
Standard deviation	1.63	0.83	1.06

*: for the male patient in his 70s who returns home after hospitalization.

VI. CONCLUSION

In this paper, we first proposed a new model for analyzing the LOS at hospitals when variances are heterogeneous. Using the proposed model, we analysed the effects of the DPC system on the LOS for cataract operations in Japan using data collected from 5 general hospitals. The estimates of the Female, Age 50, Age 90, and Not Home Dummies were significant and affected the LOS. We found large differences in the changes in ALOSs among hospitals. For the short ALOS hospitals, the ALOS did not decrease. On the other hand, for the long ALOS hospitals, the ALOS significantly decreased. The results of empirical study may imply that the DPC system gave strong incentives to reduce the LOS for the long ALOS hospitals but gave weak (or no) incentives for the short ALOS hospitals.

In this study, we only surveyed 5 hospitals. Although obtaining data before the introduction of the DPC system is very difficult, it is necessary to collect data from more hospitals to evaluate the DPC system more precisely. Furthermore, we need to perform the same analysis using other diseases. These are subjects for future studies.

APPENDIX: THE DPC SYSTEM

The DPC system is an original system developed in Japan. The DPC classifies diseases, operations, treatments, and patient conditions using a 14-digit code. The first 6 digits classify principal diseases on the basis of the International Classification of Diseases-10 (ICD-10). The remaining 8 digits pertain to information on operations, treatments, and patient conditions such as the presence of a secondary disease. Initially, the DPC system classified patients into 1,860 payment categories. Currently, the number of categories is 1,572. Inclusive payments based on the DPC system cover

fees for the following categories only: basic hospital stays, medical checkups, image diagnosis, medication, injections, treatments under 1,000 points (10 yen per point has been paid to hospitals), and medicines used during rehabilitation treatments and related activities. Fees for all other categories, such as fees for operations, are paid on the basis of the conventional fee-for-service system.

Unlike the Diagnosis-Related Group/Prospective Payment System (DRG/PPS) used in the U.S. and other countries, the Japanese DPC system is a per diem prospective payment system. The per diem payment becomes less as the LOS becomes longer. Three periods, Period I, Period II, and Specific Hospitalization Period, are determined for each DPC code. Period I is set as the 25th percentile of the LOS of the surveyed hospitals. Period II is set as the average length of hospital stay, that is, the 50th percentile (although this value is actually the median, it is called the "average length of hospital stay" in the DPC system). Finally, the Specific Hospitalization Period is given by the following equation: (average length of hospital stay) + 2 × (standard deviation). The basic per diem payment is determined according to the LOS. For stays below Period I, the per diem payment to hospitals is 15% more than the average per diem payment of the patients whose stays were within the average length of hospital stay. For hospital stays between Periods I and II, the per diem payment is determined such that (per diem payment in Period I – average per diem payments)× (number of days in Period I) equals (the average per diem payments – per diem payment between Periods I and II) × (number of days between Periods I and II). For stays between Period II and the Specific Hospitalization Period, the per diem payment is reduced by an additional 15%. For stays over the Specific Hospitalization Period, the per diem payment is determined through the conventional fee-for-service system. Furthermore, for each hospital, the actual payment amount is determined by multiplying the basic payment by the individual hospital coefficient, which is the sum of a basic coefficient and an adjustment coefficient. The adjustment coefficient is determined such that the hospital's revenue does not become less than that of the previous year. This is an incentive for hospitals to adhere to the new payment system.

In the case of cataract operations (DPC code: 021103x01x000), the per diem inclusive payment in 2005 was 2,546 points up to the third day of hospitalization, 1,882 points for the 4th-6th days, and 1,600 points for the 7th-10th days.

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